

### **Standard 3: Flow of Matter and Energy**

**The student will analyze and explain the movement of matter and energy through interactions of earth's systems (*biosphere, geosphere, hydrosphere, atmosphere, and cryosphere*) and the influence of this movement on weather patterns, climatic zones, and the distribution of life.**

#### **A. Conservation of Matter Within Earth Systems**

**Indicator 1. Demonstrate that matter cycles through and between living systems and the physical environment, constantly being recombined in different ways.**

- a. Demonstrate that the earth is a system essentially containing fixed amounts of each stable chemical element which can exist in different chemical reservoirs- in the solid earth, oceans, atmosphere and organisms- as part of the biogeochemical cycle.
- b. Describe that the movement of matter between reservoirs is driven by the earth's internal and external sources of energy and are accompanied by a change in the physical and chemical properties of the matter.
- c. Give examples to show that the atoms and molecules on the Earth cycle through the living and nonliving components of Earth's systems.
- d. Use models or diagrams to explain that the chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways.

#### **B. Energy Distribution through Earth Systems**

**Indicator 1: Analyze how the position and movement of the Earth in space determine distribution of heat and light.**

- a. Describe internal and external sources of Earth's heat including
  - Internal sources such as decay of isotopes; gravitational energy from Earth's formation
  - External source- sun
- b. Use models to explain how the tilt of the earth results in seasonal variation in temperature.
- c. Illustrate or demonstrate that different intensities of sunlight falling on different parts of the earth during the year cause variations in temperature and result in the differential warming of Earth's surfaces.
- d. Explain and diagram how greenhouse gases increase thermal energy in the atmosphere and its effect on earth's temperature and systems.

**Indicator 2: Explain that transfer of thermal energy between the atmosphere and the land or oceans produces temperature and density gradients in the atmosphere and the oceans.**

- a. Demonstrate and explain that the heating of earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans producing winds and ocean currents.
- b. Predict the movement and distribution of thermal energy through winds and ocean currents given warm and cool areas.
- c. Demonstrate and explain that in a fluid, regions that have different temperatures have different densities.
- d. Demonstrate that regions of different temperatures rise or sink or mix, resulting in winds and ocean currents.
- e. Explain that the transfer of thermal energy between the atmosphere and the land or oceans produces density gradients in the atmosphere and the oceans.
- f. Explain that the action of a gravitational force on regions of different densities causes them to rise or fall, creating currents that contribute to the transfer of energy.
- g. Use models or diagrams to explain that winds and ocean currents are affected by the earth's rotation and land masses.

**Indicator 3: Explain that transfer of thermal energy between the atmosphere and the land or oceans influences climate patterns.**

- a. Demonstrate that global climate patterns are determined by dynamic energy conditions, such as cloud cover, ocean currents, atmospheric circulation, Earth's rotation, and the Earth's various surfaces.
- b. Demonstrate that global climate patterns are determined by static conditions, such as latitude, altitude and the position of mountain ranges, oceans, lakes.
- c. Cite evidence, from such sources as plate tectonic theory, ice cores, CO<sub>2</sub> measurements, and fossil finds, to show that the earth's climate has changed in the past, is currently changing, and is expected to change in the future.
- d. Explain how plants on land and in the photic zone of the ocean alter earth's atmosphere and analyze evidence of change in the composition of the atmosphere;
- e. Cite evidence to show that changes in climate can produce very large changes in ecosystems.

- f. Cite evidence to show that earth's climates have changed in the past are currently changing and are expected to change in the future.

### **C. Interaction of Physical Systems and the Biosphere**

#### **Indicator 1. Analyze and explain the movement of matter and energy through earth's systems and the influence of this movement on the distribution of life.**

- a. Recognize and explain that the global distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials (water, carbon, nitrogen, minerals).
- b. Recognize and explain that because the global distribution and abundance of organisms and populations in ocean habitats are defined by abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate, and circulation, ocean life is not evenly distributed spatially or temporally.
- c. Recognize and explain that the global distribution and abundance of organisms and populations in terrestrial habitats is defined primarily by temperature and precipitation.
- d. Use scientific data to illustrate how critical factors and tolerance limits affect the distribution of organisms.
- e. Describe how plants on land and in the ocean alter the earth's atmosphere.
- f. Illustrate and explain that all of earth's ecosystems, both terrestrial and marine, are linked through the movement of organisms and the flow of matter and energy.